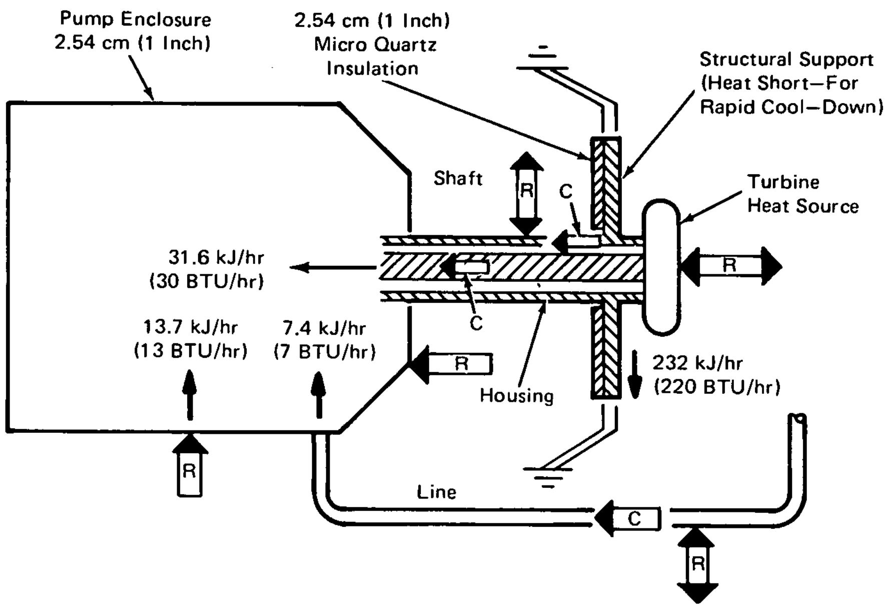
NASA TECH BRIEF
Marshall Space Flight Center

Turbopump Thermodynamic Cooling



A large amount of the heat in cryogenic systems comes from operation of the turbopumps. The hot turbine gas delivers this heat by conduction down the shaft into the propellant. Additional heating also comes from radiation from the pump enclosure and from conduction from the feed lines. This heat flux must be eliminated to avoid excessive propellant heating which could result in pump cavitation. Previous cryogenic turbopump systems required a chill-down period for the pumps prior to start-up.

The developed technique uses a thermodynamic propellant vent to intercept the pump heat at the desired conditions. It is applicable to multiple-start turbopump systems that use liquid hydrogen or to any system located near a liquid hydrogen supply that requires continuous cooling. The technique uses either hydrogen provided for the purpose or liquid hydrogen residuals which are not otherwise utilized.

Use of the thermodynamic propellant vent to maintain pump temperature greatly reduces the amount of propellant required to accommodate the heat load and allows pump start-up at any time. This configuration is well suited to systems which operate on demand where pump start-up cannot be accurately predicted. During operation of the thermodynamic vent system, liquid hydrogen is withdrawn from a propellant storage tank and expanded through a throttle device. After expansion, the liquid hydrogen, partially vaporized, is at low pressure at a temperature 4°K (7°R) below the initial liquid temperature. This two-phase mixture then absorbs the required heat until it is completely vaporized.

In the thermodynamic pump model, shown in the figure, the coolant is routed down the shaft and vented overboard. This allows the coolant to be heated above the propellant temperature as it flows down the shaft and minimizes the coolant flow required. Housing

(continued overleaf)

coolant-flow is utilized to maintain the housing temperature at or near the propellant temperature. Because the hydrogen housing coolant would still have a significant amount of heat capacity available above 22°K (40°R), it is routed to the oxygen turbopump. Sufficient heat capacity is available to meet the oxygen cooling requirements. The unique features of the innovation minimize the pump chill-down and boil-off losses, maintain turbopumps in a chilled state for a start at all times, and cut coolant requirements by almost fifty percent.

Notes:

1. Information concerning this innovation may be of interest to cryogenic pump manufacturers.
2. Requests for further information may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Code A&TS-TU
   Huntsville, Alabama 35812
   Reference: B72-10408

Patent status:

No patent action is contemplated by NASA.

Source: T. C. Patten, H. B. McKee of
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